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Annual Report *for* **1952**

**LAKE STATES FOREST
EXPERIMENT STATION**

M. B. DICKERMAN — DIRECTOR



**U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE**

ST. PAUL, MINNESOTA

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EXPERIMENT STATION

The Lake States Forest Experiment Station is located at University Farm, St. Paul 1, Minnesota. It is a regional branch of the United States Forest Service and is maintained in cooperation with the University of Minnesota. Through federal legislation, it is authorized to carry on forest research for the benefit of all forestry agencies in the region, including public forest services, wood-using industries, farmers, and other forest users.

The territory in which the Station operates includes the States of Michigan, Wisconsin, Minnesota, and North Dakota. In addition to the central office in St. Paul, field offices are located at East Lansing and Marquette, Michigan; Rhinelander, Wisconsin; and Grand Rapids, Minnesota.

29TH ANNUAL REPORT OF THE
LAKE STATES FOREST EXPERIMENT STATION

For the Calendar Year 1952

Lake States Forest Experiment Station
Maintained in cooperation with University of Minnesota
University Farm, St. Paul 1, Minnesota

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
LAKE STATES FOREST EXPERIMENT STATION



ADDRESS REPLY TO
DIRECTOR
AND REFER TO

UNIVERSITY FARM
ST. PAUL 1, MINN.

R - IS
REPORTS
Station's Annual 1952

April 30, 1953

Dear Sir:

I am very happy to send you the enclosed copy of our 27th Annual Report, which gives a brief review of Station activities for the calendar year 1952 and plans for 1953.

The forestry problems needing study are great and the means at our disposal for attacking them are relatively small. To extend the effectiveness of our staff and funds, therefore, we have developed cooperative projects wherever feasible. During 1952, for example, 44 forest industries, state, and other public agencies cooperated with the Station in forest management, forest resources, and farm forestry research. Our 1952 Annual Report, for this reason, gives special emphasis to the cooperative phases of our research work.

I hope you will find this Annual Report of interest. If you have any comments on it or any aspect of the Station's work, please send them in to us.

Additional copies of our Annual Report may be obtained on request.

Very truly yours,

M. B. Dickerman

M. B. DICKERMAN
Director

Enclosure

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LAKE STATES FOREST EXPERIMENT STATION

ANNUAL REPORT FOR 1952

INTRODUCTION

Progress in most research work is difficult to measure. In forest research this is especially true, for frequently it is necessary to wait years for studies to be completed. Consequently, this 29th Annual Report is more of a progress report, telling mostly of studies underway, setting forth a few major findings, and emphasizing the importance of cooperation. The following pages give some idea of the breadth of projects now underway and the great diversity of problems needing attention. The fact that more findings are not set forth reflects both the complex and long-time nature of forest research and the small staff and facilities currently available to pursue research work in the Lake States region.

During 1952, the Station consulted with numerous advisory groups in formulating research plans and projects. Advisory councils met and discussed problem area research for northern Minnesota, northern Wisconsin, Upper Michigan, and Lower Michigan. These four advisory council meetings were particularly helpful in getting at both the immediate and long-term research needs of forest administrators. The Station also participated in the newly formed Minnesota Forest Council and in the annual meeting of the Lake States Forest Industry Research Committee. Station representatives attended several meetings of Forest Survey advisory or steering committees which have been set up in each state for the purpose of scheduling field work, soliciting cooperative funds, reviewing draft reports, and, in some cases, following up survey recommendations.

Increased attention was given to publishing and demonstrating research findings. Some 54 Station publications, including a major bulletin, "Forest Fires and Forest Fire Control in Wisconsin," by J. A. Mitchell, were released. In cooperation with extension foresters and others, demonstration meetings were held in each state to show others the findings of research projects. In Lower Michigan, for example, nearly 300 people attended a demonstration at the Lansing Woods. On the Argonne Experimental Forest in northern Wisconsin, some 90 people turned out for the annual farm forestry field day. Numerous smaller groups observed research work elsewhere in the region.

During the year a number of changes took place in the Station organization. Dr. Ralph Anderson from the Division of Forest Pathology joined our group. This further rounds out the Station's complement of research specialists. Mr. Francis Eyre, who for many years has been in charge of forest management research, transferred to the Washington office of the Forest Service. In his 20 years with the Station, Mr. Eyre had published authoritative bulletins on the management of red pine and jack pine and participated in many other studies. His transfer represents a serious loss. Mr. Cunningham, in charge of forest economics work, was on detail to the Department of the Army for six months in Ryukyu Islands. Other changes took place too; transfers, resignations, and new appointments. In all, at the end of the year there were 39 employees.

Although they had a large number of research projects already underway, the staff initiated six major forest management studies in 1952. These include new work in balsam fir thinning and cutting methods, in regeneration and management of coniferous swamps, in regeneration of yellow birch, and in cutting methods for pole-size aspen. Continued over a period of years, these projects will provide new guides for practicing foresters.

These, in brief, have been the more important happenings at the Lake States Forest Experiment Station this past year. In the following pages, specific projects are reviewed and findings to date are presented.

COOPERATION CONTRIBUTING TO PROGRESS

Recognizing that a research program could progress more rapidly when aided by others, this Station has in recent years sought and obtained a large amount of cooperative assistance. In this report a special effort is made to show the benefits of this policy and to give acknowledgement to our current cooperators. Without such help the regional research program would be much smaller and the accomplishments would be greatly reduced.

The cooperative approach is making the federal dollar go further. By using the technical skills of our staff specialists, the staff, facilities, land, products, and cash contributions of cooperators, a diverse and comprehensive forest research program is made possible. Currently, 44 forest industries, state, and other public agencies are cooperating with the Station. The value of all the various forms of help is difficult to estimate but in total the annual value is nearly equal to the federal expenditure. There are, though, limits to how far the federal dollar can be stretched, for eventually the technical staff reaches the point where it does not have time to work on additional cooperative projects.

Examples of what cooperation has accomplished are numerous and well illustrated on the following pages. One case, though, shows in detail what can be accomplished. In Upper Michigan the advisory council recommended a study of regeneration following cuttings in swamps. The Station proposed a plan of study and after a preliminary analysis of field observations, many of which were done by cooperators, a long-term study has been delineated. Permanent plots are now being installed by two cooperators on their lands and under a plan proposed by the Station.

In addition to assistance by the national forests, the following participated in the Station's program for 1952. The help of all is generously acknowledged.

List of Cooperators in 1952

Forest Industries

American Box Board Company, Grand Rapids, Michigan
Blandin Paper Company, Grand Rapids, Minnesota
Bonifas Lumber Company, Neenah, Wisconsin
Cleveland-Cliffs Iron Company, Negaunee, Michigan
Cliffs-Dow Chemical Company, Marquette, Michigan
Consolidated Water Power & Paper Company, Wisconsin Rapids, Wisconsin
Diamond Match Company, Cloquet, Minnesota
Escanaba Paper Company, Escanaba, Michigan
Flambeau Paper Division, Kansas City Star Company, Park Falls, Wisconsin
Kimberly-Clark Corporation, Neenah, Wisconsin
Lansing Company, Lansing, Michigan
Marathon Corporation, Rothschild, Wisconsin
Minnesota & Ontario Paper Company, International Falls, Minnesota
Mosinee Paper Mills Company, Mosinee, Wisconsin
National Container Corporation of Wisconsin, Tomahawk, Wisconsin
Nekoosa-Edwards Paper Company, Port Edwards, Wisconsin
Northern Paper Mills, Green Bay, Wisconsin
Northwest Paper Company, Cloquet, Minnesota
Rhineland Paper Company, Rhineland, Wisconsin
Wood Conversion Company, Cloquet, Minnesota

Public Agencies and Institutions

Iron Range Resources & Rehabilitation Commission, Hibbing, Minnesota
Kent County Road Commission, Grand Rapids, Michigan
Michigan State College, East Lansing, Michigan
Michigan College of Mining & Technology, Houghton, Michigan
Michigan Conservation Department, Lansing, Michigan
Minnesota Conservation Department, St. Paul, Minnesota
Production and Marketing Administration, St. Paul, Minnesota,
Madison, Wisconsin, and Lansing, Michigan
University of Michigan, Ann Arbor, Michigan
University of Minnesota, St. Paul, Minnesota

University of Wisconsin, Madison, Wisconsin
U. S. Army Corps of Engineers, St. Paul, Minnesota
U. S. Bureau of Plant Industry, New Haven, Connecticut
U. S. Office of Indian Affairs, Minneapolis, Minnesota
U. S. Soil Conservation Service, Milwaukee, Wisconsin
Wisconsin Conservation Department, Madison, Wisconsin

Other Cooperators

Airplane Sprayers Association, Triangle Aviation, Inc., Stanton,
Minnesota
Atlantic Refining Company, Philadelphia, Pennsylvania
Birch Club, Gillett, Wisconsin
Chicago Northwestern Railroad, St. Paul, Minnesota
Consumers Power Company, Jackson, Michigan
Dow Chemical Company, Midland, Michigan
E. I. du Pont de Nemours & Company, Minneapolis, Minnesota
Lewis B. Ingalls, Skandia, Michigan
Mitts & Merrill, Inc., Saginaw, Michigan

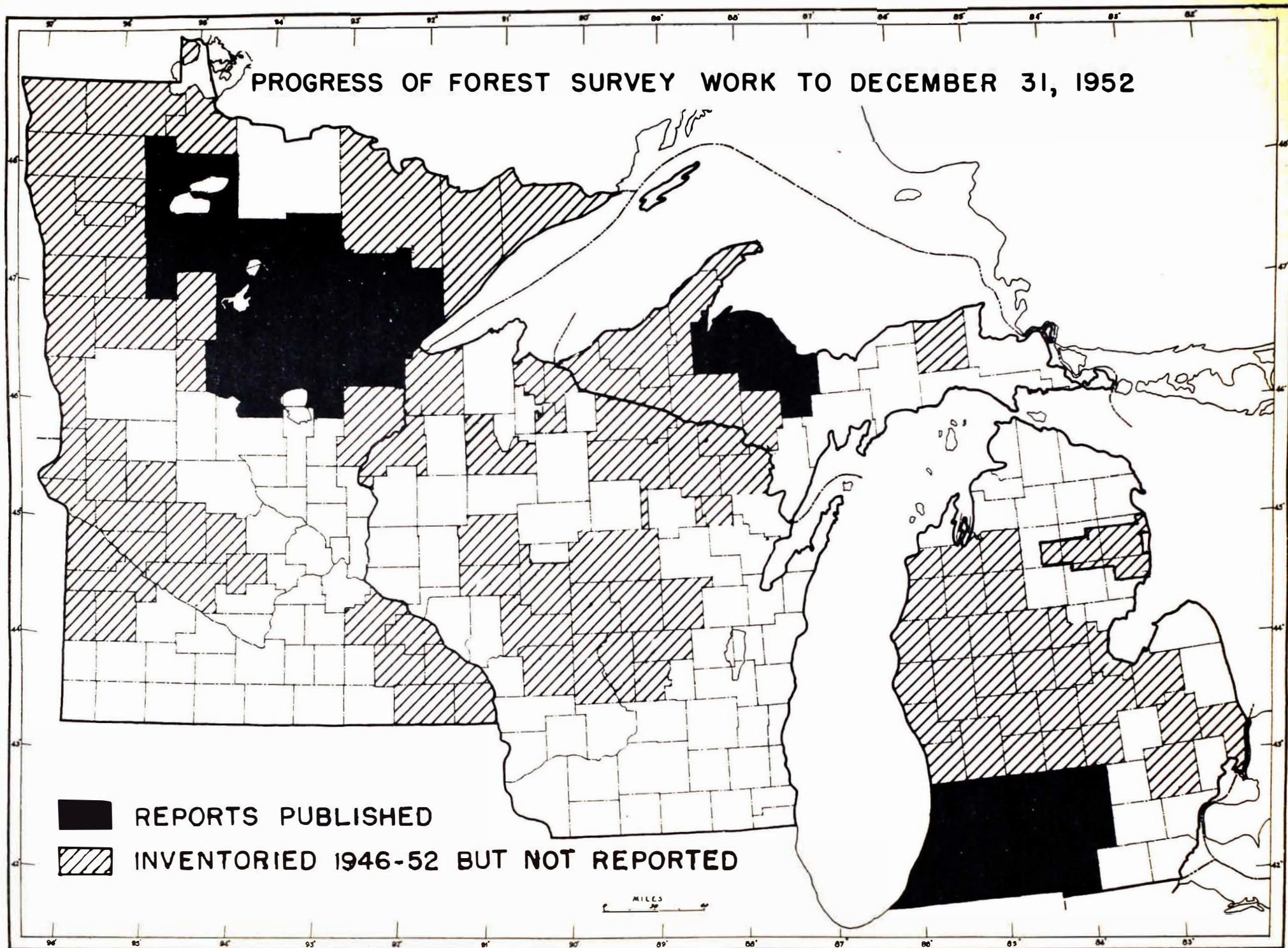
THE FOREST SURVEY

The Forest Survey in the Lake States is a big cooperative job -- 5 federal, 8 state, and about 45 county agencies take part in it, directly or indirectly. Practically all of the wood-using industries support the survey by supplying production reports and, in many cases, funds.

The Lake States Station has endeavored to set the overall pattern for the survey, coordinate the work of the several agencies, and fit the whole into the National Forest Survey. In its direct participation, the Station has concentrated primarily on the items of growth, drain, and allowable cut. One man has been working full time on timber drain and requirements records and studies. One man has assisted the Minnesota survey and made growth and allowable cut studies. One man has directed field work in Michigan. This year for the first time a Station man has been available for field work in Wisconsin. Men from the central office have worked on survey techniques, plans, and reports, and participated in training sessions and assisted as needed along the line.

Since July 1946, slightly more than one million dollars have been spent on the Forest Survey in the Lake States, about 25 percent of which came from the Station and 75 percent from the states, forest industries, and other cooperators. Actually, the cooperators have spent much more than this if there are included aerial photography and management plan surveys as directly benefiting the Forest Survey project.

PROGRESS OF FOREST SURVEY WORK TO DECEMBER 31, 1952



Minnesota

Minnesota has approximately 19 million acres of forest land; roughly 7 million acres in state and federal forests, 4 million in county forests, and the rest in farmwoods or other private ownership. As of December 31, 1952, field inventories have been completed on 14.6 million acres of forest in Minnesota. Printed reports have been issued for 8 counties and have been prepared for early publication for 14 additional counties. A state summary report is planned for 1954.

National Forests, the Office of Indian Affairs, and the Minnesota Department of Conservation have assumed responsibility for surveying the organized state and federal forests and intermingled holdings of other owners. The Office of Iron Range Resources and Rehabilitation, a State agency, has been doing most of the work on county and private lands. Since 1946, it has maintained a crew of six or more men in the field. Also it has been publishing the results of the survey in a series of county reports.

Several pulp and paper companies have helped to buy new aerial photographs for survey purposes, and two of them have assisted with inventory field work.

During the past six years these several cooperating agencies have expended approximately \$343,000 on the survey while the Station has spent \$92,000 of federal Forest Survey funds.

One outstanding result of the Minnesota survey to date has been the effect on timber sale policy on public forests, especially on county lands. With definite knowledge of the quantity, kind, and location of their timber stands, several counties have been able to accelerate their timber sale business without fear of depleting their growing stock. Clearwater County, for example, increased its sales of pulpwood from about 1 thousand cords in 1946 to 7 thousand cords in 1952. The Chippewa National Forest, likewise, approximately doubled its allowable cut after completion of new survey and management plans.

Wisconsin

Wisconsin has about 17 million acres of forest land, including 2 million acres in national and Indian forests, 3 million in state and county forests, and 12 million in farm and other private holdings. As of January 1, 1953, field inventories have been completed on 7.6 million acres. No reports have been published yet but five and possibly more county reports will be issued during the coming year.

As in other Lake States, the U. S. Forest Service and Office of Indian Affairs have assumed responsibility for surveys within the boundaries of their several forest units.

Outside of federal projects, a cooperative survey organization operates under the direction of the State Department of Conservation. Cost of the operation, exclusive of contributions of the Lake States Forest Experiment Station, are shared approximately as follows: 40 percent by the State Conservation Department, 30 percent by northern counties, and 30 percent by forest industries. Most of the large pulp and paper companies are contributing to the cost of the Wisconsin survey. In addition, a considerable number of lumber companies, veneer companies, some railroads, power companies, and others are participating. Expenditures of cooperators to date have been about \$284,000 while those of the Station have been \$58,000.

Michigan

In Michigan there are about 19 million acres of forest land, including 2½ million in federal forests, 4 million in state and county forests, 4 million on farms, and 8½ million in other private holdings. As of January 1, 1953, field inventories have been completed on 11.3 million acres or 59 percent of the area to be surveyed. Reports have been published by the Department of Conservation for 15 counties and have been prepared for early publication for 13 additional counties.

In Michigan, the Conservation Department and this Station have shared about evenly in the expense of the Forest Survey. During the past two years one pulp and paper company has maintained a man full time on the survey crew. The administrative branch of the U. S. Forest Service has surveyed two national forests and assisted in other ways. The Forest Products Research and Forest School Divisions of Michigan College of Mining and Technology, Michigan State College, the University of Michigan, and several wood-using industries have helped with the survey in one way or another. Altogether, cooperators are credited with \$132,000 and the federal Forest Survey funds with \$125,000 spent on the survey.

It is going to be very interesting to compare the timber volume estimates from the current survey with those of the survey made in 1936. Figures which have been summarized so far indicate a fairly large decline in volume in the Upper Peninsula but larger volumes in the Lower Peninsula.

Regional Drain Studies

The Station has been making cutting surveys and publishing an annual drain report on a region-wide basis in addition to participating in the drain phase of the county-by-county cooperative surveys. Information on production and drain has been obtained mainly from questionnaires mailed to forest industries. We have had excellent cooperation from forest industries in these surveys.

A summary of pulpwood production statistics published in our Technical Note No. 384 in October 1952 shows that pulp cutters in this region have harvested about 2 million cords per year as an average over the past decade. Those in Minnesota have cut the most, those in Michigan next, and those in Wisconsin least. One very interesting trend over the period has been the shift in species. Cutters marketed 935,000 cords of aspen in 1951 compared with 322,000 in 1942. They have increased their cut of pine more moderately; kept the yield of spruce and balsam fairly even; but, reduced their cut of hemlock.

Annual Pulpwood Production in the Lake States by Species

1942 - 1951

(Thousand standard cords, rough-wood basis)

Species	Annual production										
	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	Average (9 years)
Pine	356	292	484	1/	493	510	493	273	345	544	421
Spruce- balsam	683	526	816	1/	674	701	838	638	634	768	698
Hemlock	365	282	419	1/	314	199	182	108	131	220	247
Aspen	322	258	380	1/	714	562	625	486	694	935	553
Miscellaneous softwoods	17	13	22	1/	24	26	10	4	2	19	15
Miscellaneous hardwoods	2/ 10	4	10	1/	31	26	36	43	66	90	35
Total	1,753	1,375	2,131	2,000	2,250	2,024	2,184	1,552	1,872	2,576	1,969

1/ Figures not available.

2/ Includes small quantity of waste, slabs, etc.

FOREST MANAGEMENT RESEARCH

A major goal of the Station's full-time research since its inception in 1923 has been to seek and report information on the silviculture, regeneration, growth, and yield of Lake States timber types. Almost from the start, state universities, conservation departments, and forest industries provided cooperation which furthered the Station's work.

During the past five years, the amount of cooperative help on Station projects has increased. In 1952, assistance in forest management research projects was provided by 27 agencies: 16 private, 3 federal, 3 state conservation departments, 4 state universities and colleges, and 1 county. Cooperative projects have concerned chiefly harvest cutting methods, stand improvement practices, and regeneration of unsatisfactorily restocking areas.

Harvest Cutting Studies

Good forestry requires the knowledge of how to cut various timber types so as to get the greatest yield of useful products and provide for adequate reproduction of desirable species. Past research has given useful guides to harvest cutting methods for jack pine, red pine, and black spruce; although additional information is desirable for these types. There is urgent need for such information also for other important timber types in the Lake States. Research is underway in aspen, northern hardwoods, balsam fir, spruce, oak, and coniferous swamp types as well as in the jack pine, red pine, and black spruce types.

Aspen

Aspen is the most extensive forest cover type (about 20 million acres) and has become the principal domestic source of pulpwood in the Lake States. The urgent demand for more information on handling this species has resulted in several projects, some of them cooperative. Two were active in 1952.

Aspen Cut-Over Survey (In cooperation with Consolidated Water Power and Paper Company).

Some 45 aspen cut-over areas were examined in northern Wisconsin and the Upper Peninsula of Michigan to learn the effects of various cutting practices in regenerating the stand. The survey was planned and directed by the Station. The Consolidated Water Power and Paper Company and the Nicolet, Chequamegon and Upper Michigan National Forests made available records on some of their cutting. Personnel of Consolidated Water Power and Paper Company participated in the field survey.

The survey indicated the need for better woods utilization and more complete cutting of mature areas of aspen. The heavier the cutting, the more abundant and vigorous was the subsequent crop of aspen sprouts and suckers. Observations made of proper age of cutting on different sites, trends in natural conversion, and losses from biotic factors also will be evaluated.

A manuscript relating the findings is partially completed.

Cutting Methods in Bigtooth Aspen (In cooperation with the University of Michigan and the American Box Board Company).

The need for more information on aspen management in Lower Michigan is increasing because of expanded industrial uses for aspen and because bigtooth aspen, relatively little studied, is much more abundant here than elsewhere in the region. One cutting-methods study was installed during the fall of 1952 with field assistance from the American Box Board Company and the University of Michigan. Three 10-acre cutting compartments are being logged in a 35-year-old stand predominantly of bigtooth aspen. This study will provide more knowledge about the economics and silviculture of cutting from "above" or "below" as contrasted with clear cutting.

Logging cost comparisons should be available for distribution in 1953.

Northern Hardwoods

The northern hardwood forest, covering over 9 million acres in the Lake States, contains more than one-third of the sawtimber area in the region. It is of special interest to furniture, flooring, chemical, wooden ware, and other industries which require sugar maple, yellow birch, basswood, American beech, or eastern hemlock logs. Second-growth stands provide a useful reservoir of domestic timber for the pulp and paper industry. Cooperation has furthered Station studies chiefly in the Upper Peninsula of Michigan, where the bulk of the remaining sawtimber stands occur. Four such projects were active in 1952.

Determining the Best Methods of Managing Northern Hardwoods (In cooperation with the Cleveland-Cliffs Iron Company and the Cliffs-Dow Chemical Company).

In 1926, the Cleveland-Cliffs Iron Company, through a donation of land, aided in the establishment of the Upper Peninsula Experimental Forest and in the establishment of a series of experimental cuttings to determine the best methods of managing northern hardwoods. Several of these study units are over 20 years old and are yielding valuable information to forest managers in the Lake States. The true value of these experiments is increasing because forest experiments are long-time studies that must be carried on for many years before final conclusions can be reached. During the last two years

the company assisted in logging the second cut on several of the cutting units. The Cliffs-Dow Chemical Company has assisted in the project by taking cordwood from tops and cull logs, otherwise not utilizable. This is one of the few study areas in the United States where long-time timber growth records and second cut information are available to practicing foresters and students.

A manuscript based largely on this study, "Twenty Years of Partial Cutting in Northern Hardwoods in the Lake States," by F. H. Eyre and W. M. Zillgitt, has been submitted for publication as a government bulletin.

Logging Damage Study (In cooperation with the Cleveland-Cliffs Iron Company and the Bureau of Plant Industry).

The second cutting of the old sample plots on the Upper Peninsula Experimental Forest provided an opportunity to assess the decay which starts as a result of logging injury in selectively cut hardwood stands. The Cleveland-Cliffs Iron Company is cooperating by sawing selected trees on which logging damage records are available. At the time of sawing, the progress of decay and amount of degrade in lumber attributable to logging damage was studied by a pathologist employed by the Bureau of Plant Industry. After another season's work on this project, a valuable publication will result.

Mortality in Hemlock Following a Heavy Partial Cut (In cooperation with the Cleveland-Cliffs Iron Company).

The mortality of hemlock following a heavy partial cut was studied on the Upper Peninsula Experimental Forest in cooperation with the Cleveland-Cliffs Iron Company. In 1944, a mature hemlock-hardwood stand was logged to remove 70 percent of the volume. For the seven years following logging, mortality per year averaged less than one percent of the volume. For hemlock alone, it was about 1.5 percent. Gross annual growth, after deducting mortality, has been about four times greater than mortality. This study indicates that heavy post-logging mortality does not always follow partial cutting of mature hardwood-hemlock stands. The heavy cutting which left the younger and thriftier trees may have been the principal reason for the low rate of mortality.

Reproduction After Cutting in Hardwood-Hemlock Stands.

Hardwood-hemlock stands will be followed by reproduction adequate in number of trees but less desirable in composition according to a study of three stands recently made by the Station in the Upper Peninsula of Michigan. The original stands averaged about 18 M board feet gross per acre in volume. One was clear-cut; about half the volume was cut on another; and the third was uncut. The proportion of quadrats stocked with one or more healthy seedlings or saplings was 100 percent on the clear-cut, 99 percent on the

partially-cut, and 94 percent on the uncut area. Red maple reproduction was most common. Sugar maple was present on 80 to 90 percent of the quadrats in the cut stands. Yellow birch occurred on 88 percent of the clear-cut and 60 percent of the partially-cut quadrats but usually was overtopped by red maple or sugar maple. Hemlock was present on 23 percent of the clear-cut and 44 percent of the partially-cut quadrats. Hemlock and yellow birch constituted over 60 percent of all stems 5 inches d.b.h. and larger in the original forest but are minor species in the new stands. The trend in the reproduction is towards an increase of red maple and sugar maple at the expense of hemlock and yellow birch.

Financial Feasibility of Desirable Management Practices in the Northern Hardwood Forest (In cooperation with Lewis B. Ingalls of Skandia, Michigan).

On a 1400-acre management unit, the Station is studying costs and returns of good forest management practices and also attempting to develop technical procedures that will enable the forest manager to budget annual cuts to attain optimum growing stock and continuous income. Mr. Lewis B. Ingalls of Skandia, Michigan, who has been logging on this area for the past four years under a cooperative agreement, is furnishing complete information on logging and milling costs, lumber grade recovery, products recovery for the various species, and selling cost data necessary for the financial appraisal of the operation.

Swamp Conifers

The major source of the highly valued spruce pulpwood in the Lake States is the 6-1/3 million acres of conifer swamp types. Past studies have dealt largely with the black spruce swamps, so little information has been obtained concerning desirable silvicultural systems for the tamarack, northern white-cedar, or mixed conifer swamp types. To help fill this gap in our knowledge, several co-operators have joined with the Station in a comprehensive project on management of mixed conifer swamp forests, two phases of which were active in 1952. Additional studies in black spruce management were also made.

Methods of Cutting Mixed-Conifer Swamps to Obtain Reproduction (In cooperation with Escanaba Paper Company, Bonifas Lumber Company, Northern Paper Mills, and Michigan Conservation Department).

During 1950 and 1951, the Station and its co-operators made a survey of swamp cuttings in the Upper Peninsula of Michigan. Results of the survey, published as Station Paper No. 27 in December, showed that an adequate stocking of reproduction followed most cuttings in the mixed swamp forests but that the new stand had more swamp hardwoods at the expense of the more desirable conifers.

This survey clarified the need for research in methods of cutting mixed-conifer swamps so as to maintain the place of the valuable conifers in the new stand. As a result, these same cooperators are now assisting with the installation of a study to determine the amounts and kinds of reproduction and timber yields resulting from even-aged and uneven-aged management methods in mixed coniferous swamps. Each of the cooperators is furnishing the land and manpower to establish at least one replication of the study. Two replications are being installed this winter (1952-53), one by the Escanaba Paper Company at Newberry, Michigan, and one on the Upper Peninsula Experimental Forest. Five more replications will be established during the winter of 1953 and 1954. The wide distribution of these tests will provide reliable information for swamp management in this territory.

Cutting Swamp Black Spruce (In cooperation with the Minnesota Forest Service).

Black spruce swamps are the source of much of the high-grade pulpwood produced in the Lake States. How to cut this extremely variable type so that production will be kept as high as possible without further serious reduction in growing stock is the object of an extensive cutting experiment now underway on the Big Falls Experimental Forest.

Here, the Station in cooperation with the Minnesota Forest Service, is cutting black spruce swamps by methods aimed at even-aged and all-aged management. A total of seven treatments have been replicated three times, giving 21 cutting units of six to ten acres each.

The Station has done all the marking, has established and measured some 200 permanent sample plots and is responsible for all computations. The State Forest Service has supervised the sale of the timber and has been responsible for scaling it.

A study of logging damage to reproduction, reported in 1952, showed that one-fifth to one-third of the stocking of advance reproduction was lost as a result of logging. Losses were heavier in clear-cut than in partial-cut areas. No significant differences in damage were detected between horse and wheel-type tractor skidding.

Costs of Managing Black Spruce (In cooperation with the Minnesota Forest Service).

To learn the costs and returns from good forest management of black spruce forests, a 760-acre management unit was set aside on the Big Falls Experimental Forest in the summer of 1952. The Minnesota Forest Service assisted the Station in installing and making the initial measurements of some 400 permanent sample plots. On the basis of these plots, the stand will be estimated and a management

plan made in cooperation with the State. The area will be managed as a going business, using the best known silvicultural practices. The State Forest Service will make the necessary sales on areas recommended by the Station and will furnish us with a record of all returns. Records of costs and returns will be kept by the Station.

Oak

There are almost 4 million acres of oak forest in the Lake States. The most productive areas occur in the southern part of the region, largely on farms. One of the most perplexing silvicultural problems in this area is to obtain natural regeneration following cutting in the typically even-aged stands of northern red oak. These oak forests are extremely valuable. As a usual thing, commercial clear cutting in mixed oak stands results either in woody shrubs - hazel, raspberry, blackberry, and grey dogwood - taking over the site or in the replacement of oaks by such light-seeded tree species as elm, maple, ash, aspen, or paper birch. If the woodlots are heavily grazed prior to logging or are burned immediately after, bluegrass and weeds may eliminate the forest cover completely.

There has been a dearth of research in oak forest management in this region. However, the Station with aid of cooperators has begun studies in this field, three of which were underway in 1952.

Regeneration and Methods of Cutting Northern Red Oak (In cooperation with the Wisconsin Conservation Department and the State Extension Forester).

The scarcity of northern red oak seedlings in mixed oak stands is not a matter of insufficient seed supply. Bumper yields of acorns occur every four or five years and fair crops occur at two to three year intervals. Something happens to the acorns after they reach the ground or to the young oak seedlings. The question is: What?

Experiments now underway near Galesville, Wisconsin, are expected to solve at least some of the problems relating to the regeneration of northern red oak. Several years ago direct seedings were made under a closed canopy of mature timber. Both screened and unscreened spots were used. Losses to rodents definitely were higher on the unprotected spots. Seedlings which did become established have been followed carefully. In general, their development has been slow or unsatisfactory.

Within the past two years, two 1/2-chain by 1 1/2-chain exclosures and checks were erected. Both direct seedings and planted stock will be used in these tests. The direct seedings have been completed. Losses to date have been chiefly from rodents. One or more seedlings germinated in 94 percent of all screened spots, whereas on unscreened checks the ratio of success varied from 61 to 81 percent. There was no initial damage from rabbits or deer, but the factor of overtopping by annuals and woody plants may prove to be serious.

Another series of tests involved scarification of certain areas with an Athens disk after the acorn crop of 1950 had fallen. Preliminary checks indicate that disked plots had 2,390 red oak seedlings per acre in July 1951 as compared to 770 for undisked checks.

Mixed Oak Management (In cooperation with the Lansing Company and Michigan State College).

During 1952, a 10-year lease was obtained from the Lansing Company (a manufacturer of wooden implement parts) to use 40 acres of mixed white and red oak sawtimber on a good site in Lower Michigan for research management purposes. The first harvest cut removed approximately 30 M board feet of lumber. Cost data were collected on the felling, bucking, skidding, and sawing operations. Each log was graded and the lumber grades received from each log were tallied with the cooperative assistance of the Forestry Department at Michigan State College. At the time of harvest, a forestry demonstration was held under the general supervision of Michigan State College Extension Foresters. Approximately 300 people saw the cutting and were informed of the forest management objectives in this stand.

Less Oak Reproduction on Better Sites (In cooperation with Michigan State College).

Both the number and species of oak reproduction vary with the quality of site according to studies conducted in Lower Michigan. The proportion of oak reproduction decreases as the quality of the site increases. On very poor sites approximately 50 percent of the reproduction is composed of oak species, whereas on very good sites the proportion of oak reproduction found is less than 5 percent of the total.

Balsam fir-Spruce

Balsam fir-spruce forests, a major source of valuable pulpwood, occupy some 3½ million acres in the Lake States. Their regeneration and management is of major concern to the pulp and paper industry. The Station has undertaken several studies in this type in recent years. Results of one study were reported in 1952.

Disking to Regenerate Pulpwood Species (In cooperation with Rhinelander Paper Company).

Excellent natural reproduction following disking in a good seed year was obtained in a cooperative study on the industrial forest of the Rhinelander Paper Company in northeastern Wisconsin. In August 1950 (at a cost of \$4 to \$7 per acre), strips were torn up at intervals of 10 feet using a heavy disk in a patchy stand of sapling and pole balsam fir and paper birch. One year later there were about

308,000 new seedlings per acre on the disked area as compared to almost none on the untreated strips. Considering the whole area (disked and untreated) there were about 185,000 seedlings per acre. On the disked portion, 95 percent of the quadrats were stocked with new seedlings. Stocking, in percent, by species was 82 for paper birch, 58 for balsam fir, 32 for red maple, 12 for aspen, and 2 for spruce. Despite heavy mortality anticipated, this stand should be well stocked with desirable species.

Stand Improvement Research

Under forest management, new stands succeed the old following harvest cuttings. These new stands need tending to assure that the best trees of the best species develop in adequate numbers to utilize the productivity of the site. There are more than 30 million acres of such young stands, including one million acres of established plantations in the Lake States. Sometimes brush or undesirable tree growth must be removed because it overtops the preferred tree species. At other times, over-dense stands must be thinned to maintain uniform and good growth on the crop trees and to utilize trees which would die. Continuing research is needed to point out when and how improvement practices can best be made for several million acres in various types, ages, and conditions of stands common in the Lake States. Not only effective but also economic methods must be sought.

The Station has carried on thinning and release experiments since the early days of its existence and has reported available results in a number of publications. Many studies are current, 11 of which are aided by several cooperators.

Response of Red Pine to Release (In cooperation with the Michigan Conservation Department).

Many of the one-half million acres of red pine plantations in the Lake States are overtopped and suppressed to varying degrees and for different periods of time by hardwood trees and brush. To determine how long red pine can be suppressed and still respond to release, the Lower Peninsula Forest Research Center established a study in the spring of 1950. Nine replications were installed on national and state forest land in northern Lower Michigan. The Station planned and carried out the study and the Michigan Conservation Department and the Lower Michigan National Forest made available several tracts containing older suppressed red pine plantations which would have been difficult to locate elsewhere.

Preliminary results of this study, to be published in 1953, show that red pine suppressed by oak for as long as 40 years will respond and grow after release. There was relatively little response to release the first two years after treatment, but measurements three years after treatment showed that even the most badly suppressed trees in the completely released plot grew twice as fast in height as the least suppressed trees in the unreleased plot.

Costs and Effects of Chemical Release (In cooperation with the Dow Chemical Company).

The release of plantations from competing low-value hardwoods has become an exceedingly important job in plantation management. Where should the conventional axe method of girdling the larger hardwoods and cutting the smaller ones be used, and where should the newer chemical methods be tried? Such release is a costly operation, so the Station and the Dow Chemical Company have been conducting chemical herbicide tests during the past three years to find more economical release methods.

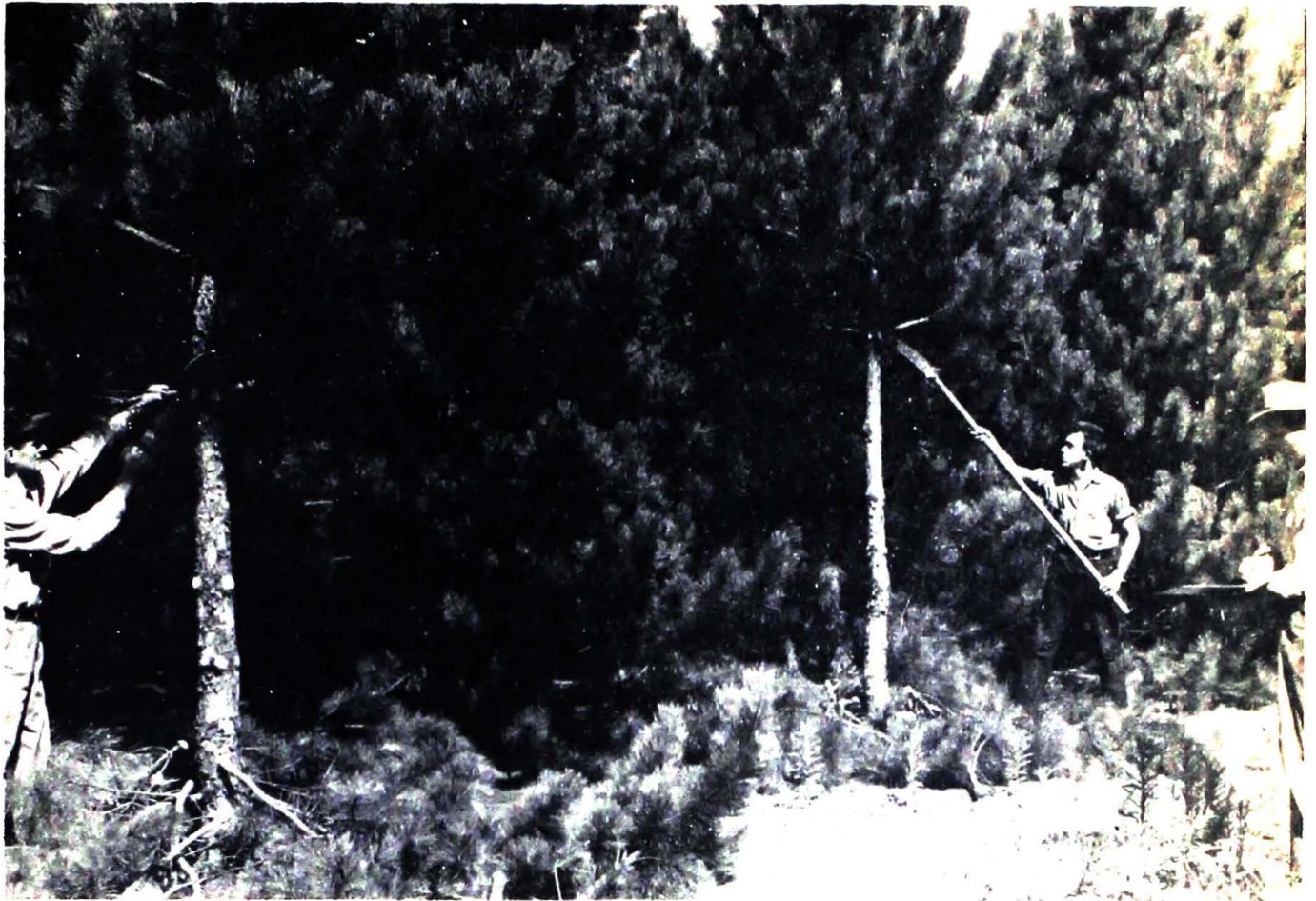
In 1952, results were published which showed that basal sprays of 12 pounds of 2,4,5-T ester per 100 gallons of diesel oil are very effective for controlling individual scrub oak, aspen, and red maple trees. Not only are the tops of the trees gradually killed, but sprouting is retarded for about three years. However, the costs of the chemical, added supervision, and difficulty of transporting large volumes of herbicide through the woods for extensive pine release work have reduced the practical value of basal sprays in forest management work to limited operations. Although labor costs in man-hours for the actual basal spray work (2.8 per acre or 0.05 per square feet of basal area treated) are considerably less than for girdling (7.8 per acre or 0.21 per square feet of basal area treated), the delay time in refilling the sprayers and added supervision increase the initial release costs above conventional axe release costs on most operations. However, basal sprays when properly applied are very effective in retarding sprouting of the species treated for two to three years.

Control of Scrub Aspen with Basal Sprays (In cooperation with the Dow Chemical Company).

Basal sprays with 8 to 12 pounds acid equivalent of 2,4-D and 2,4,5-T esters mixed with diesel oil are very effective in killing the tops of scrub aspen. Few to no root suckers are found the first year after treatment. However, most trees treated during the dormant and early growing season sucker the second year after treatment. Scrub aspen treated with basal sprays between the time of full leaf development and the dormant season have not suckered three years after the treatment was applied. This is the first positive control measure found for controlling aspen without prolific sprouting and suckering.

Chemical Frill Girdling (In cooperation with the Dow Chemical Company).

Tests of chemical frill girdling (making a continuous cut around the tree at a convenient chopping height and adding a small quantity of 2,4,5-T mixed with diesel oil to the frill) reveal that this method of controlling scrub oak, aspen, and red maple may have practical application in pine release work. The initial costs of controlling the tops of scrub oak by chemical frill girdling on a 100-acre test



Pruning planted red pine. Limby trees do not produce quality wood products. For maximum returns, limby trees to be grown to sawlog size should be pruned (usually not more than 200 per acre). Research is underway to determine the effects of pruning to different heights at various stages of development and the costs of such practices.

were one half the cost of regular axe girdles. In addition, sprouting was greatly reduced. This method of chemical release appears to be very practical in forest management work on an extensive scale.

The Effect of Pruning Intensity on Red Pine Growth (In cooperation with the Kent County Road Commission, Consumers Power Company, and the Michigan Conservation Department).

Plantation grown pines, because of regular spacing and understocking in the early years after establishment, normally have large branches which do not prune naturally for many years. Indications are that knot-free wood cannot be produced in red or white pine plantations in less than 80 years without artificial pruning.

Since red pine makes up a major portion of Lake States plantations and is one of our more valuable softwood timber trees, a study was initiated in the fall of 1950 to test the relationship of growth to severity of pruning red pine of four different height classes (8, 16, 24, 32 feet). Red pine in 11 locations representing different site conditions in Lower Michigan were pruned to 30, 50, 70, and 90 percent of total height. The study was planned and installed by Station personnel on land made available by the Lower Michigan National Forest, Consumers Power Company, Kent County Road Commission, and the Michigan Conservation Department.

Results in 1952, after three growing seasons, indicate that up to 50 percent of the total height (which also amounted to about 50 percent of the live crown length) can be safely pruned without retarding growth. On the other hand, pruning 70 percent of the total height retarded growth.

Annual Pruning and Red Pine Growth (In cooperation with the Kent County Road Commission).

In recent years there has been considerable interest in annual or bud pruning methods which involve removing the lateral buds or branches of coniferous trees each year. Since red pine is one of the species most naturally adaptable to this form of pruning, an experiment was started in the fall of 1950 to determine the silvicultural and economic possibilities of different systems of annual pruning.

The test was designed and established by the Station in plantations furnished by the Kent County Road Commission and the Lower Michigan National Forest.

Short-time information gives some promise that a form of annual pruning, in which both the top and bottom whorls of branches are left on the tree and the one-year-old whorl is removed each year until the tree reaches the desired clear length, may produce the most clear lumber in the shortest possible time.

Growing Stock Levels in Red Pine (In cooperation with the Consumers Power Company and the Michigan Conservation Department).

The proper amount of growing stock for maximum quantity and quality growth at different ages and for different spacings on various sites must be determined for the thousands of acres of planted red pine in the Lake States. Thinning schedules are needed for all possible growth and developmental conditions. Accordingly, a thinning study was planned and initiated in 1950 in Lower Michigan red pine plantations as follows: (1) The first replication was established on the Higgins Lake State Forest in the summer of 1951. Michigan Conservation Department foresters helped with the plot layout, marking, and furnished plot posts and labor for their installation. (2) During the spring of 1952, the second replication was installed by the Station on land made available by the Lower Michigan National Forest on the Tawas District. (3) Consumers Power Company, Jackson, Michigan, provided the land and red pine plantation near Newaygo, Michigan, for the third replication. Company foresters assisted with the entire job of reconnaissance, plot establishment, and helped to mark the study for thinning.

Basal area levels from 60 to 190 square feet are being tested. All of the thinnings have been commercial operations with the material going into pulpwood. If a market had been available for small pine fence posts, the thinnings would have had a higher value for this use.

Since this is a long-time project and only recently installed, preliminary results will not be available until about 1955.

Control of Scrub Oak by Chemical Means (In cooperation with the Nekoosa-Edwards Paper Company).

Foresters are becoming more and more wary about calling any forest tree a weed tree. However, scrub oak on poor sites, or where it has been burned repeatedly by past forest fires, still seems to warrant the name. On certain selected sites, therefore, it is desirable to eliminate scrub oak in favor of more valuable species if this can be done at reasonable cost.

Tests made by the Station with the Nekoosa-Edwards Paper Company gave a top kill of over 85 percent without subsequent resprouting of scrub oak by placing a tablespoon of ammonium sulfamate crystals in axe cuts placed at 6-inch intervals around the base of the trees. Pine reproduction responded well to the release obtained. Such control appears feasible where there are only a few hundred scrub oaks per acre.

Other chemicals, notably 2,4,5-T in diesel oil, are also being tested as basal sprays in an attempt to find cheaper methods of doing the work in denser stands. In such tests the cooperating company provides land, labor and materials for tests and the Station personnel works with them in installation of observational plots and in follow up on the trials, particularly as it may affect growth of residual pine or reproduction.



A recently thinned red pine plantation -- the cut trees have been converted into pulpwood. Research is aimed at learning what stand density is best for producing the best quantities and qualities of wood at given ages on various site conditions.

Thinning Young White Spruce Plantations (In cooperation with the Office of Indian Affairs, Menominee Indian Reservation).

The proper spacing of white spruce and its thinning is a point of interest to Lake States foresters because increasing amounts of this species are being planted in the Lake States.

In late 1948 and early 1949, the forestry staff of the Menominee Indian Reservation worked with the Station in installation of a series of 12 plots in a 23-year-old plantation originally spaced two by four feet and averaging around 3,830 living trees per acre. Indian Service personnel did the thinning operation and worked with Station personnel in plot measurement. Thinnings were made to leave residual stands per acre of 750, 1,000, 1,250, 1,500, and 1,750 trees. First results will be available after the 5-year remeasurement in the fall of 1953.

Thinning of Young Sapling Jack Pine by Mechanical Means (In cooperation with the Nekoosa-Edwards Paper Company and Mosinee Paper Mills Company).

The concept of thinnings is almost as old as the history of forestry. However, doing the job at reasonable cost by mechanical means, other than hand cutting tools, is a rather new approach to the subject.

In 1948 and 1949, the Station cooperated with Nekoosa-Edwards Paper Company and the Mosinee Paper Mills Company in installation of a number of mechanical and hand thinning plots in dense young jack pine with the multiple purpose of increasing growth rate, reducing mortality by snow and ice bending and breaking, and at the same time appraising costs on the operations. Thinning was done with a self-propelled circular power saw, an Athens disk, and hand tools. Of the mechanical methods used to date, the self-propelled circular power saw appears to be the best, doing the job at a cost of only 34 percent that of hand thinning; the power saw thinning costs were about \$7.19 per acre.

Thinning Northern White-Cedar Swamps (In cooperation with Wisconsin Conservation Department).

Northern white-cedar, of special value both for the production of wood and winter deer browse, frequently grows in very dense stands. Accordingly, in January 1947, an experiment was laid out near Pembine, Wisconsin, in a deer yard within a mixed-conifer swamp, predominantly of northern white-cedar but also containing black spruce, balsam fir, and other species. The study was aimed to show: (1) response of the residual stand to thinning; (2) response of reproduction to thinning; and (3) the deer feed values from mid-winter thinning, especially in foliage of white-cedar felled in thinning, and in the reproduction of white-cedar which might originate as a result of stand opening.

Conservation Department personnel worked with the Station in laying out the area for thinning and supervised the thinning. Station personnel subsequently laid out 20 one-twentieth acre plots in the center of each half-acre thinning plot. Results will not be available until after the first remeasurement in 1957.

Commercial Thinnings in Balsam Fir (In cooperation with the Minnesota Forest Service).

About one-third of the area of the balsam fir type on both state and national forest lands in Minnesota is in pulpwood stands. Stands of this class, like the older stands, show considerable loss from mortality, much of which could probably be eliminated by regular commercial thinnings. Therefore, an experiment was begun in cooperation with the Minnesota Forest Service to study the possibilities of such thinning in increasing pulpwood yields through reduction of mortality and also increases in growth.

About 20 acres of 50-year-old balsam fir near Big Fork have been marked for cutting by four different methods and will be logged this winter. In addition to making the area available for study, the State Forest Service has assisted with the survey and subdivision of the tract, marking of the timber and the location of 40 permanent sample plots. The Station staff has measured the plots prior to logging and will be responsible for all computations.

Power-Saw Girdling in Timber Stand Improvement.

Girdling of cull trees with a one-man power saw reduced actual time expended by nearly two-thirds and cash outlay by about one-half compared to axe girdling in tests made in second-growth hardwoods on the Argonne Experimental Forest in northern Wisconsin. Used was a 30-pound one-man power saw with a kerf-teeth chain which cut a kerf of about 0.55 inch. The operator held the saw blade against the tree and walked counter-clockwise until the tree was completely girdled through the cambium area. One and one-half years after treatment none of the clean, complete girdles had healed over, and often the cambium had died back one-half to one inch from the girdle.

Response of Balsam Fir to Release.

Although balsam fir makes fair growth under stands of aspen and paper birch, it will reach pulpwood size much faster if released according to data recently obtained on the Pike Bay Experimental Forest in northern Minnesota. Early in 1935, five acres of balsam fir were released by complete removal of an aspen-birch overstory. Fifteen years later this balsam fir provided a cut of 4 to 14 cords per acre of pulpwood. On the surrounding untreated area, the balsam fir had made fair growth but was much too small for a merchantable cut.

Labor Costs for Thinning Young Aspen.

Silviculturally it is desirable to thin overdense young quaking aspen stands on good sites at an early age according to studies made by the Station over the past 23 years. Economically, the desirability of such thinnings will depend on increased values resulting from the treatment weighed against the cost of thinning carried over the period.

A study of non-commercial thinnings made in 11- and 20-year-old aspen on good sites in northern Minnesota gave labor costs of 11 man-hours per acre for thinning the younger stand as compared to 17 man-hours for the older one. Even if costs at present wage rates are projected at 4 percent compound interest, the earlier thinning still is more economical. An analysis based on yields 20 years after treatment indicated that thinning at age 20 gave enough increase in merchantable products to more than offset the costs of thinning, considering interest and all other costs. The earlier thinning indicated even better returns.

Regeneration

Following fires or cutting practices unsatisfactory in execution or timing, stands frequently fail to reproduce themselves. Often grass, brush, or weed trees take over the site and unless artificially reforested many such areas will not bear valuable forests for a long time to come. Other areas have understocked sapling or pole stands which could be brought up to fuller production by planting or seeding. It is estimated that 9 to 12 million acres in the Lake States will require planting to restore them to productivity in reasonable time. Because of their importance, much of the past research of the Station has been on regeneration problems - seed, nursery, or planting - and several projects were active in 1952.

Seed Production of a White Spruce Tree

White spruce, one of the most valuable and widely planted Lake States conifers, normally produces heavy crops of seed every 2 to 6 years and lighter crops in most intervening years. Because it is not known how much seed white spruce trees can produce in good years, records were kept of the production of an open-grown tree 15 inches d.b.h. and 75 years old on the Kawishiwi Experimental Forest in northeastern Minnesota. In 1948, this tree produced 11,874 cones which fell from the fall of 1948 through the intervening months until the next fall. On the average, each cone contained about 65 seeds of which 23 were viable. This tree then produced about 271,000 viable seeds, the equivalent of about one pound of commercial clean seed, in a good seed year. Trees of comparable age and size would, of course, produce fewer cones under stand conditions, but it is apparent that mature white spruce trees in northern Minnesota can produce a large number of viable seeds in good crop years.

A Manual of Nursery Practices.

Since 1937, the Station, in cooperation with Region 9 of the U. S. Forest Service and some state agencies, has made numerous studies of density of sowing, root pruning, methods of sowing, soil fertility, chemical weed control, stock storage, and other nursery practices. Results of this research along with the experience of federal and state nurserymen in the region has been combined into a comprehensive nursery manual for the Lake States. First draft of the manuscript has been completed; after review and revision it will be submitted for publication in 1953.

Test of Nursery Weed Killers (In cooperation with Wisconsin Conservation Department, Soil Conservation Service, private commercial tree nurseries, and several chemical manufacturers).

Weed control has been an expensive item in the overall cost of producing nursery stock. In an effort to cut costs, various chemicals have been tested by the Station with the active cooperation of several nurserymen who have made space available and aided in installation and observational work. Several chemical companies have contributed materials. The Station has often made the initial tests and prepared plans for pilot-scale tests and in instances installed these tests or made observations.

The use of mineral spirits as a selective herbicide is now a rather standard practice in the larger conifer nurseries. State Conservation Department nurseries in Wisconsin annually are saving about \$20,000 in weeding costs by using mineral spirits.

Among promising new chemicals tested by the Station are C.M.U. as a nursery weed control. It is a wettable powder and, when applied at 2 pounds per acre in water immediately after seeding, has greatly reduced weed stands in red pine, jack pine, and white spruce beds. Because C.M.U. is a potent herbicide in heavier applications, plans are underway for a series of study and pilot-scale plots on other species, especially hardwoods, to determine safe levels of treatments.

Use of Wetting Agents in Direct Seeding (In cooperation with the Atlantic Refining Company).

In view of the high cost of planting these days, foresters are interested in any technique which shows promise of cost reduction, whether in the nursery or during the planting operation. Accordingly, a small study was made during the past summer at two research centers to determine if the detergent product, Ultrawet, had any effect on seedling survival. The centers put in the study on small plots on both light and heavy soil, treating seed spots of red pine after sowing, with different concentrations of Ultrawet.

Tests made in northern Minnesota showed that first-year survival of red pine seedlings improved with increase of concentration of the Ultrawet on a heavy soil, but decreased on a light soil. Results in Lower Michigan were obscured by drought conditions; they were inconclusive.

Susceptibility of Sweetfern to Chemical Herbicides (In cooperation with the Dow Chemical Company).

The eradication of sweetfern by an inexpensive method would be of value in preplanting release work and in pasture improvement work, since this woody plant is an invader of open land in the northern portions of the Lake States region. The effectiveness of 2,4,5-T esters, brush killer (combination of 2,4-D and 2,4,5-T esters), and a low volatile ester of 2,4-D as a means of sweetfern control when applied in different concentrations, volumes, and carriers during the dormant and growing seasons of the year, was tested in northern Lower Michigan during 1951. The Station planned and carried out the field work in cooperation with Dow Chemical Company on national and state forest land in Lower Michigan.

In general, the results to date have been disappointing. However, it was learned that the low volatile ester of 2,4-D applied as a foliage spray in an oil carrier, at rather low concentrations, is at least as effective as the more expensive esters of 2,4,5-T in higher concentrations.

Airplane Spraying of Low-Land Brush (In cooperation with Minnesota Forest Service, Minnesota and Ontario Paper Company, Dow Chemical Company, and Airplane Sprayers Association).

A large area of the black spruce swamp forest in northern Minnesota has been converted to worthless brush by fire following logging. Planting here will be prohibitive in cost unless some relatively inexpensive means can be found to reduce brush competition. Since spraying with herbicides from planes elsewhere has been found successful in killing or checking the growth of brush, a small-scale study was set up in August 1951 near Effie, Minnesota. About 15 acres of state land covered with alder, willows, and dogwood were sprayed with a mixture of 2,4-D and 2,4,5-T in fuel oil. The chemicals were supplied by the Dow Chemical Company and the spraying done by Northeast Airways of Virginia, Minnesota. The State and the Minnesota and Ontario Paper Company laid out and marked the plots and assisted the Station in making stem counts to evaluate the results.

Initial kill was excellent from both 1.14 and 3.26 pounds of acid per acre. There has been more resprouting from the lighter spraying, but so far this is not serious enough to justify the almost three-fold higher cost of the heavier spraying. A final appraisal of the success of the job must wait for three or four years to see if black spruce transplants can develop successfully without expensive release.

Genetics

One way to improve the productivity of our forests is to make sure that new forests are reproduced only from parent trees of the best genetic qualities. This can be done in part by (1) roguing present stands so that only the best trees remain during the reproduction period, (2) planting or seeding with stock or seed of races or strains proven better than the local trees, and (3) the development and use of superior well-adapted hybrids. The Station has done considerable research in racial variation and has tested several hybrids developed elsewhere. Several projects are active, two of which are reported here.

Effect of Age of Parent Tree on Jack Pine Reproduction.

That the development of jack pine seedlings apparently is not affected by age of parent tree has been brought out by a study in Lower Michigan. Seed was collected from trees in seven 10-year age classes (11-20, ... 71-80 years old). Stock was planted on a uniform soil in 1940. After 14 growing seasons from seed, the trees grown from different aged parents varied only from 13.6 to 14.0 feet in average height and 1.9 to 2.0 inches d.b.h.

Regional Jack Pine Seed Source Study (In cooperation with University of Minnesota, Minnesota Conservation Department, Wisconsin Conservation Department, Michigan Conservation Department, Mesinee Paper Mills Company, Nekoosa-Edwards Paper Company).

A regional study to compare jack pines grown from seed produced by good stands from 29 localities throughout the Lake States was begun with collection of the seed in 1951. The study has been planned jointly by the Station and the University of Minnesota. Half the seed collections were made by various cooperators. Seed extraction was done by the University of Minnesota and testing and distribution for sowing by the Station. Seed was sown in the nursery in the spring of 1952, half at the Hugo Sauer Nursery of the Wisconsin Conservation Department and half at the General Andrews Nursery of the Minnesota Conservation Department. Field planting is planned for the spring of 1954. Several cooperators will participate in the planting and later follow-up.

FARM FORESTRY STUDIES

Some of the best forest land in the Lake States is owned by farmers. Yet these farm woodlots commonly are producing far below capacity because of neglect or mismanagement. At the same time, farmers buy a great deal of wood for building and fencing, much of which they could grow themselves. Recent work of the Station is placing emphasis on ways and means of increasing the income from farm woodlands.

Farm Woodland Management

(In cooperation with the Wisconsin Conservation Department, University of Wisconsin, Michigan Conservation Department, Michigan State College.)

To show farmers how to handle their woodlands, the Station for several years has managed typical tracts of 40 acres in the Upper Peninsula of Michigan, northeastern Wisconsin, and north central Minnesota. It has cooperated with state agencies in similar handling of nine Timber Harvest Forests in Wisconsin and two woodlots in southern Michigan. On these areas, annual or biennial demonstrations have shown several hundred farmers each year what products can be harvested by cutting the equivalent of growth, what the woods look like before and after cutting, and what returns can be expected from such management. These same areas yield valuable research information on allowable cut, growth, stand structure, silvicultural methods, and regeneration.

In Wisconsin, the first cutting cycle has been completed for the Wausaukee Timber Harvest Forest (white pine-Norway pine type) and the Chilsen Timber Harvest Forest (second-growth hardwoods). A preliminary analysis indicates that the quality of the timber on both areas has been improved by the first series of harvests, and there is almost as much growing stock in the stand as there was at the outset. For example, on the Wausaukee tract, 20 sample plots showed 87.7 square feet of basal area per acre at the beginning of the 1948 growing season; the corresponding figure after the 1952 growing season was 83.5 square feet per acre, including ingrowth. The cut during the 5-year period was 17.4 square feet per acre and mortality was 0.5 square feet. At the present growth rate of 10.1 square feet of basal area per acre per year, the stand will be better stocked in 1954 than it was in 1948.

Farm Fencing Studies

(In cooperation with the University of Minnesota)

Minnesota farmers use some 15,000,000 fence posts a year, about half of which are wooden. Past studies have shown that when properly preserved and driven, wooden posts have no superior. Therefore, farmers can obtain most of their fence posts from local wood. To facilitate adequate local preservative treatment of wooden posts, the School of Forestry, University of Minnesota, in cooperation with the Station, has developed a pilot vacuum treating plant which can be built for about \$6,000. During 1952, several thousand jack pine and tamarack posts were treated with pentachlorophenol to determine the potential use and limitations of such a treating plant, and to establish the required vacuum and treating cycle which would give adequate preservative treatment. Seasoned jack pine posts took preservative treatment readily with either a 15-, or 25-inch vacuum. The total treating time for each charge was less than an hour, including loading and unloading the tank. A somewhat larger plant has been built and successfully operated by a private lumber dealer in Minneapolis.

Because little is known about the preservative treatment of tamarack, the 1952 tests, in addition to the vacuum process, included cold soaking, commercial pressure, and hot-cold bath treatments of posts peeled in different ways and cut at different seasons. None of the treatments of tamarack was entirely satisfactory, but the winter-cut, lathe-peeled posts given the hot-cold penta treatment proved to be the best.

FOREST FIRE RESEARCH

One of the major contributions fire research has made to fire control is in the development of ways and means for rating burning conditions. The current use of burning index ratings has become standard practice in the day-to-day administration of fire control. Also, to an increasing extent, burning index ratings have been found useful in overall planning and in evaluating results of the fire control effort.

During the past year, the Station has placed emphasis on case studies in the Lake States to determine, for specific protection units: (a) the normal severity and seasonal distribution of burning conditions, together with the probable variation from normal to be expected; (b) the relation of burning conditions to fire occurrence and fire size; (c) the seasonal variation in risk or the chance of fires starting; and (d) the normal fire load and its seasonal distribution in terms of potential and acute fire days.

On the Chippewa National Forest, for example, a case study showed that for the past 16 years there was an average of 79 potential (low to moderate) and 63 acute (high or worse) fire days a year with standard deviations of + 10 and 11 respectively. A protection organization based on such average conditions would be ample half of the time, while one based on the average number of potential and acute fire days plus their standard deviations should be adequate five years out of six. The analysis indicated that an organization capable of handling 89 potential and 74 acute fire days a year is called for on the Chippewa National Forest.

In the same case, the importance of the seasonal distribution of the fire load was apparent. Involved are not only the seasonal distribution of burning conditions but also the risk of fire occurring. On the Chippewa, burning conditions are normally high in both spring and fall. Risk, or the chance of fires starting, however, is largely confined to spring. As a result, 63 percent of the fire load normally occurs in April and May, while only 11 percent occurs in October. The possibility of abnormal seasons, however, makes it necessary to be prepared, on an emergency basis, for acute conditions at any time of year.

Setting of performance standards and the evaluation of results presents a problem too. The number of fires and the forest area burned provide a measure to judge the effectiveness of fire control, but they do not tell the whole story. Obviously more fires and a larger burn are to be expected in bad years than good. Consequently, in judging the effectiveness of the protection effort, both the severity of the fire season and current risk must be taken into consideration. In the case of the Chippewa, after taking into account the severity of burning conditions, it was found that there had been an overall decrease in the chance of fires starting but that the effectiveness of the suppression effort has been decreasing. While adequate on the basis of present standards, this is a trend that will bear watching since the chance of a "blow-up" increases as the effectiveness of control decreases.

While present "goals" or standards as to number of fires and annual burn indicate a desirable ceiling, they do not provide for judging the effectiveness of fire control effort from year to year, for they leave burning conditions and risk out of the picture. As a result, the standard set may be too high in normal years and too low in bad years. This was found to be the case on the Chippewa. To meet the situation, a table was prepared based on the correlation of number of fires and area burned with burning conditions and risk, showing the number of fires and annual burn to be expected at various levels of seasonal severity and risk.

This case study points out how some of the questions that arise in connection with fire control administration can be answered by fire research. Further work along this line, however, is called for to provide a broader basis for the regional determination of what should be considered adequate fire protection.

FOREST WILDLIFE RESEARCH

(Conducted by the Fish and Wildlife Service in cooperation with the Forest Service.)

During 1952, forest wildlife research was directed mainly toward (1) an appraisal of range recovery in exclosures for deer, moose, and snowshoe hares, (2) an analysis of data pertaining to the birds of Isle Royale National Park, (3) the collection of deer hunting statistics during special open seasons on the Mud Lake and Tamarac National Wildlife Refuges, (4) a study of the effects of several methods of cutting mixed coniferous swamps in obtaining tree reproduction and shrubs of value for deer food, and (5) to a study in methods of clipping mountain maple to determine proper utilization by deer.

The latter two of these projects were started in the fall of 1952. Some of the findings from two of the projects have been summarized below.

Effect of Moose Browsing on the Vegetation of Isle Royale National Park

Four exclosures for moose have been established by the Fish and Wildlife Service to obtain information on the recovery of vegetation when browsing is prevented. The first exclosure was built in 1948, two were constructed in 1949, and the last one was completed in 1950. A comparison of field data gathered in 1950 and 1952 showed that the feet of live stem increased by 51.2 percent within the exclosures. In contrast, the control plots had an increase of only 18.9 percent. These differences in growth clearly demonstrate the effect of moose browsing on the vegetation.

Effect of Deer Damage on Forest Plantations

Deer damage to planted and natural jack pine seedlings has been observed in the Lower Peninsula of Michigan for several years, but actual measurements of such damage have not been generally available. In 1949, an exclosure was constructed in a jack pine plantation in which 2-0 stock had been set out in 1947 and replanted in 1948 because of deer damage. A comparison of field measurements gathered in 1949 and 1951 showed the protected seedlings suffered

no mortality and the total height of all trees increased 128 to 178 percent in two years. The unprotected seedlings suffered from 23 to 31 percent in mortality and had a lower height growth. All mortality and height reduction was attributable to deer browsing.

FOREST PATHOLOGY

(Conducted by the Bureau of Plant Industry, Soils, and Agricultural Engineering, Division of Forest Pathology, in cooperation with the Forest Service, the University of Minnesota, and private industry.)

During 1952, forest pathology research was directed mainly toward (1) a study of factors influencing the incidence of Hypoxylon canker in aspen stands, (2) the northern hardwood defect problem, (3) the determination of whether or not there are races of white pine blister rust, and (4) the root rot problem of white pine at the Chittenden Nursery, Wellston, Michigan.

Factors Influencing the Incidence of Hypoxylon Canker of Aspen

This study, started four years ago, has progressed largely because of the extensive and active participation of the pulp and paper industry. Results obtained during the earlier phases of the study indicated that stand density and stem exposure might be important factors. During 1952 a series of thinning plots was established to determine the influence of such thinnings on susceptibility to infection. Another study was initiated to determine whether the exposed trees at the edge of a stand are more susceptible to infection than those within well stocked stands. Preliminary results, based on rather small samples from Minnesota and Wisconsin, indicate that there are about twice as many infections on the exposed trees. Some permanent plots were established in aspen stands to study the Hypoxylon canker problem on a long-term basis.

Defects in Northern Hardwoods

In 1952, a study of defect in hard maple was initiated at the Dukes Experimental Forest in Upper Michigan to determine: (1) the relationships between various types of injuries, primarily those resulting from logging damage that occurred when partial cuts were made in a stand at a known time in the past, and the resulting amount of decay and degrade, (2) what important decay organisms are involved. Some results of this study will be available next year.

Races of White Pine Blister Rust

Many fungi are able to develop new races, or varieties, which are capable of infecting plants which were resistant to those races of the fungus formerly prevalent. At the present time, considerable interest and effort are being directed towards developing varieties of white pine that are resistant to blister rust infection. Accordingly, a study was initiated three years ago in cooperation with the Bureau of Entomology and Plant Quarantine and the University of Minnesota to determine (1) whether or not the white pine blister rust fungus is composed of a number of races, or varieties, differing in their ability to infect white pines, and (2) what the probabilities are of new and more virulent races developing that might invade previously resistant varieties of white pine. The results of this study to date are largely inconclusive.

White Pine Root Rot

The white pine root rot at the Chittenden Nursery in Michigan has received attention for a number of years. The Dow Chemical Company has cooperated by providing and applying various chemicals to test their ability to control the disease. To date the problem remains unsolved. The various fungicides, insecticides, and fumigants tested have given inconclusive results.

FOREST INSECT RESEARCH

(Conducted by the Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine, Milwaukee, Wisconsin, in cooperation with the Forest Service.)

Forest insect research in 1952 dealt chiefly with studies of the biology and ecology of certain defoliating and sucking insects and of the effects of environment and biotic agents on their abundance. In addition, there were follow-up examinations of white-pine weevil control aerial spraying experiments.

Studies of Defoliating Insects

Sawflies continued to be of major importance. Although populations of the red-headed pine sawfly remained low throughout most of the region there were localized outbreaks on the Chequamegon National Forest. Several other species of pine sawflies increased noticeably in numerous localities in the Lake States and there is evidence of a resurgence in populations in the near future throughout the North Central Region. A water suspension of the polyhedral bodies of a specific virus disease of the European pine sawfly, developed by



The red-headed pine sawfly on jack pine. This insect defoliates and often kills young pines in the Lake States and elsewhere. Entomological research is seeking control measures more economical and effective than those now known.

the Canadian insect pathology laboratory, was used successfully against this insect in spray experiments in pine plantations in Illinois; a very high larval mortality resulted within two weeks. An advantage in this type of control operation is the very small amount of virus concentrate necessary for a control operation -- 2.8 cc. of suspension per gallon of water, or 1,872,000,000 polyhedral bodies per gallon. The spray can be applied as a mist using back pack sprayers fitted with a special nozzle, calibrated to deliver 2 gallons of spray per hour. The larch sawfly caused noticeable defoliation in tamarack stands in Minnesota for the fifth consecutive year, but up to the present time there has been no serious decadence of larch directly attributable to sawfly feeding. Ecological investigations were continued in 1952 to obtain basic information with which to formulate recommendations for controlling this tamarack insect if conditions warrant this step.

The jack-pine budworm remained in outbreak form in north central Michigan. In cooperation with the Federal and State Forest Services collections of overwintering and mature larvae, pupae, and eggs were made at 13 designated stations in the western third of the Huron National Forest and adjacent State Forests for the purpose of studying the parasite-predator complex. These studies will be continued in close cooperation with similar work at the eastern and western stations to determine the degree of control effected by these biological agencies.

Studies of Sucking Insects

The Saratoga spittlebug has caused a considerable amount of tree mortality and twig killing in red pine and jack pine plantations for the past 10 years in Michigan and Wisconsin. Local outbreaks occurred in northern Wisconsin and Upper Michigan in 1952, and there is some evidence that there was an increase in feeding damage not yet noticeable as "flagged" branches. Studies of red pine growth patterns were directed toward the establishment of suitable criteria for evaluating sub-economic injury due to spittlebug feeding. These growth patterns revealed drastic deterioration even before flagging. When spittlebug injured trees were sprayed and the adult population controlled this deterioration was halted abruptly and a return to normal growth occurred the following year.

Studies in White-Pine Weevil Control

The major portion of the investigational work on the white-pine weevil was for the purpose of determining the degree of reinfestation following DDT spraying in plantations in Lower Michigan. Jack pine trees, 15 feet in height, were sprayed by helicopter in the spring of 1950, and there was a noticeable reduction in terminal

mortality that season compared to the mortality in 1949. There was a slight increase in infestation in 1951, but a decline occurred in 1952 and the infestation in sprayed and non-sprayed areas is now essentially similar. Although there has been a general decline in infestation in plantations in the taller height classes there has been a substantial increase in young jack pine plantations averaging 4 to 6 feet in height; as high as 33 percent of the trees were weeviled in 1952.

PLANS FOR 1953

Most forest research projects are of a long-time nature. Accordingly much of the Station's program in 1953 must concern studies already underway. Our program is reviewed annually, however, not only within our own organization but also by representatives of private, state, and other federal agencies through the research center advisory councils and forest survey steering committees. As a result, with the completion of some studies and continuing re-evaluation of current projects, there usually is room for a few new studies. Several are proposed for 1953.

The number of projects on which research is urgently needed exceeds the time and personnel available. The Station is making a determined effort to extend the effectiveness of its staff by entering into a large number of cooperative projects. In some fields, additional cooperation would be welcome. Most of the new work planned for 1953 will involve various cooperators, but the limit has almost been reached for taking on new projects with the present staff except by dropping going studies. The Station's effectiveness is retarded through lack of a Forest Utilization Service to bridge the gap between basic utilization studies and their application in the field and through lack of work in the farm woodland area of southern Wisconsin and Minnesota.

With these limitations in mind, it is planned to emphasize the following studies in 1953:

Forest Economics

1. Plans call for completing the current Forest Survey inventory field work by 1955 and issuing final summary reports in 1956. Meanwhile, attention is being given to studies and plans for keeping the inventory fresh and up to date in the years which follow. In 1953, a considerable number of semi-permanent sample plots will be staked for later remeasurement (to check on growth, drain, mortality, and rate of conversion between types). Improved methods and equipment for photo interpretation will be studied and more efficient sampling and computing techniques will be worked out. The Station plans to continue its annual drain surveys indefinitely.

2. Since the current forest survey cycle was started in 1946, some new questions have been introduced which will require additional study in this region. Among these are:
 - (a) Causes of timber mortality -- what proportion of annual loss is chargeable to fires, insects, disease, windthrow, animals, suppression, etc.?
 - (b) Rate of natural regeneration -- how rapidly are deforested lands being restocked, and how fast are softwoods and other hardwoods replacing aspen? These points enter the calculation of potential future growth and yields.
 - (c) How much of the current inventory is actually available and operable? A clear-cut answer cannot be expected but much can be inferred from analyses of stand quality, accessibility, and ownership.
 - (d) Intensity of utilization -- a special study is proposed to learn what becomes of mill residues in typical plants in several wood-using industries.
 - (e) Long-range prospects for growth and yield -- if present stands will be properly managed, what yields may reasonably be expected by 1970 - 1980 - 2000? What will likely be the trends in species, sizes, quality, etc.?

Forest Management

1. Work in the balsam fir type, expanded in 1952, will be increased further. More methods of cutting studies will be undertaken in cooperation with the Minnesota Conservation Department, and a non-commercial thinning study will be started.
2. Aspen research will include observations on reproduction following cooperative cutting tests in bigtooth aspen in Lower Michigan and new tests will be made in a younger stand; a study of factors affecting productivity of quaking aspen sites; observations on effectiveness of chemicals and hypoxylon canker in thinning out quaking aspen.
3. Results of a study of oak sites in southern Michigan will be published as a bulletin by Michigan State College. Further study of oak regeneration and some factors affecting it will be made in southern Wisconsin and Michigan. In Lower Michigan, oak management studies will be expanded.
4. Cooperative performance tests of a portable wood chipper will be made on oak, aspen, and red pine in Lower Michigan. The study may be repeated in other localities.

5. A comprehensive report on the results of 20 years' cutting practices in old growth northern hardwoods will be published as a government bulletin.
6. The manuscript of the bulletin on nursery practice in the Lake States will be completed.
7. Plantation management studies will include additional observations on pruning in red pine and white pine in Lower Michigan, a commercial thinning in a 40-year-old red pine plantation in northern Minnesota, and a thinning in a dense 35-year-old red pine plantation in Lower Michigan.
8. A number of cooperative aid projects are under consideration, three of which have been definitely arranged: (a) a study of the relations of soil moisture to thinnings in planted red pine with Michigan State College; (b) a study of shelterbelt thinning with the University of Minnesota; and (c) a study of the genetic compatibility of various red pine strains with the University of Wisconsin.
9. Several phases of genetics research will be carried on: (a) hybrids of jack pine, lodgepole pine, and the two parent species grown at the Hugo Sauer Nursery from seed supplied by the Institute of Forest Genetics will be field planted in several localities; (b) plantation sites will be selected and laid out for the jack pine seed source study; and (c) work plans will be prepared for a cooperative planting of Danish hybrid willow cuttings purchased by several pulp and paper companies; the Station will put in one replication in northern Wisconsin.

Farm Forestry

1. Annual or periodic harvests and demonstrations on the farm forestry units will continue, and publications will be prepared on the results of managing the Upper Peninsula farm forestry forty and the Wausaukee and Chilsen Timber Harvest Forests at the close of the first cutting cycles.
2. Up to 1,000 tamarack posts will be treated in the vacuum plant in an attempt to work out satisfactory methods for this species. A bulletin, "Building Better Farm Fences," will be completed.

Fire Research

Plans call for: (1) rounding up and summarizing available information in regard to forest fires, forest fire control, and forest fire research in the Lake States; and (2) the compilation and analysis of observations made in the course of several years' field study of the modifying effect of cover on the moisture content of forest fire fuels.

Wildlife Studies

The deer exclosure project will be expanded to include the Tamarac National Wildlife Refuge and the Wisconsin National Forests. To be published soon is a summary of the deer hunting statistics for the Tamarac and Mud Lake National Wildlife Refuges in Minnesota. Information on the birds of Isle Royale National Park will also be published. Two projects begun in the fall of 1952 will be given special consideration: (1) a study of the effects of different methods of cutting mixed coniferous swamps in obtaining tree reproduction and shrubs of value as deer food, and (2) a study in methods of clipping mountain maple to determine proper utilization by deer.

Forest Pathology

1. The study of Hypoxylon canker in aspen will be continued along the lines established in past years. It is planned to establish four or five replications of a thinning plot study. Additional permanent study plots will be established. The study of exposed trees vs. those within well-stocked stands will be continued to provide a more adequate sample. Although no new studies of the problem have been definitely planned, it is realized that more basic research is essential regarding the host, especially the mode of infection, and the parasite complex.
2. The study of defect in hard maple will be continued.
3. The white pine blister rust race study will be continued along the same lines as in the past. A number of evergreen Ribes species have been obtained which will be tested to determine how feasible the use of such species will be for winter work in the greenhouse.
4. The white pine root rot study will be continued with special emphasis on determining whether or not a pathogen is involved and if so what kind.

Forest Entomology

1. Detailed studies on pine sawflies will be resumed because there is evidence of a resurgence in populations of a number of sawfly species. The virus disease control experiments against the European pine sawfly will be continued.
2. The larch sawfly project will be expanded to include (1) spring cocoon collections to account for causes of overwintering mortality, (2) correlation of oviposition and defoliations, (3) studies of larval mortality due to drowning following heavy rains and high water.
3. Continued will be studies of the jack-pine budworm parasite-predator complex and of the feasibility of employing silvicultural practices in the management of jack pine as a means of preventing severe damage by the budworm.
4. Basic research on growth patterns in red pine will be continued in order to be able to predict the course of spittlebug populations and the magnitude of sub-economic injury -- prerequisites to accurate interpretations of damage surveys and recommendations for control.

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PERSONNEL 1952

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